

IBM Technical Papers Published Recently in Other Journals

Addressing Multidimensional Arrays, H. Hellerman, *Communications of the Association for Computing Machinery*, **5**, No. 3, 205-207 (April, 1962).

A useful method of representing a function of n variables is to consider the function to assume its values at selected points in n -dimensional space. Although this picture is of value to the analyst, the elements of an n -dimensional array must exist in conventional storage as a linear array or vector. The means of performing the transformation of a set of indices locating an array element in n -space to the location (address) of the element in its storage vector is the subject of this paper. It is noted that the index address transformation is computationally identical to the conversion of a number from a fixed to a mixed radix number system. Several ways of implementing the transformation are described.

An Analog Input and Output System for a Real-Time Process Control Computer System, C. A. Walton, *Proceedings of the 1962 Joint Automatic Control Conference*, **13**, 4.1-4.6 (June, 1962).

An analog input-output system for real-time process control applications is described. The input system provides signal filtering and matching circuits for each individual input channel. The analog-to-digital converter has a fully floating, transformer-coupled input and is able to convert low-level millivolt signals without a stabilized linear low-level d-c pre-amplifier. The analog output system is fail-safe and controls motor driven set-point positioners. Much of the system described is used in the IBM 1710 process control system.

Analysis and Design of Externally Pressurized Gas Bearings, I. C. Tang and W. A. Gross,* *American Society of Lubrication Engineers Transactions*, **5**, No. 1, 261-284 (April, 1962).

Equations for flow rate, pressure, load and stiffness of externally pressurized thrust and journal bearings are given for purely viscous isothermal gas films with longitudinal or radial flow and no relative surface motion. Charts are presented which allow the bearing characteristics to be evaluated in terms of the bearing parameter, the bearing configuration, and the ratio of supply to ambient pressure. Sample characteristics of thrust and journal bearings are established using the curves, and experimental confirmation is shown. A method of treating bearing films with two inlet-restricting orifices in series is described.

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Analysis of a File Addressing Method, G. Schay and W. G. Spruth, *Communications of the Association for Computing Machinery*, **5**, No. 8, 459-462 (August, 1962).

This paper presents a new file addressing method based on the calculation of an address from the identification of a record. For large recirculating type files, it seems to be more advantageous than customary ones. The probability distribution of the displacement of records from their calculated address, which is one less than the number of probes required to address a record, is computed on the basis of a Markov chain model.

An Application of Generalized Linear Programming to Network Flows, R. E. Gomory and T. C. Hu, *Journal of SIAM*, **10**, No. 2, 260-283 (June, 1962).

The synthesis of a network is formulated as a problem in linear programming. Since the number of inequalities is usually too large, the idea of a decomposition principle is used to avoid treating all inequalities simultaneously.

The Application of Hypercomplex Matrix Analysis to Variable Parameter Networks, S. Krongelb, J. J. McNichol and N. Kroll,* *IRE Transactions on Microwave Theory and Techniques*, **MTT-10**, 236-251 (July, 1962).

The hypercomplex matrix methods developed to treat variable parameter elements are reviewed. The application of these techniques to the linear analysis of networks of variable parameter elements is demonstrated by considering a specific problem. A network containing two resonated variable capacitors separated by one-eighth wavelength of transmission line is first considered by the phase-dependent admittance method. A partial treatment of the subharmonic case is given by this method to provide a physically plausible understanding of the network behavior. The complete problem is treated by the hypercomplex matrix methods. The discussion of the results illustrates how the network properties are determined from the mathematical formalism. Calculated characteristics of the two-capacitor network are given for several values of circuit parameters.

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Band Theory of Anisotropy, J. C. Slonczewski, *Journal of the Physical Society of Japan* (Proceedings of International Conference on Magnetism and Crystallography, Sept., 1961), **17** Supplement B-I, 34-36 (March, 1962).

Until now the cubic ferromagnetic anisotropy at 0°K has been calculated by integrating the fourth-order spin-orbit energy

correction over the volume enclosed by the unperturbed Fermi surface S . We show that the change in occupation of states caused by the spin-orbit perturbation of the Fermi surface introduces an additional term into the cubic anisotropy which is proportional to the integral over S of the second-order energy squared. The tendency for cancellation of these two terms is so strong in the case of degenerate bands, such as those of iron-group metals, that the effect of including the new term is to reduce the calculated anisotropy greatly. An analytic calculation based on a simple band structure resembling Fletcher's computed nickel bands suggests that the correct value may be 200 times smaller than that calculated by Fletcher.

Base Region Transport Characteristics of a Diffused Transistor, D. P. Kennedy and P. C. Murley, *Journal of Applied Physics*, **33**, No. 1, 120-125 (January, 1962).

A one-dimensional analysis is given on the minority carrier transport characteristics of a transistor base region containing an arbitrary drift field distribution. This field is assumed to enhance (or retard) the motion of minority carriers between an emitter and collector junction, thereby modifying the influence of bulk recombination mechanisms. Base region transport efficiency is established in terms of the transistor current gain when an ideal emitter junction is assumed. Applications of this analysis are demonstrated by establishing the base region transport efficiency for diffused transistors. Two types of structures have been analytically investigated: the alloy-diffused transistor, containing a diffused collector junction and an alloy-type emitter; and the double-diffused transistor constructed entirely by diffusion techniques. For practical semiconductor devices, a comparison of these two structures has shown negligible differences in their base region transport efficiency and, furthermore, the drift mechanisms within these diffused devices have little influence upon their one-dimensional current gain.

Bounded-Transient Automata, S. Winograd, *Switching Circuit Theory and Logical Design* (Proceedings of the Third Annual AIEE Symposium), 137-141 (September, 1962).

A bounded-transient finite automaton is an automaton for which a single change of an input will not affect the output "far away." This paper investigates the class of events which bounded-transient automata can compute and shows that this class of events is a generalization of the class of definite events. A method of determining whether or not a finite automaton is bounded-transient is described, and the connection between the results of this paper and Kilmer's results is indicated.

Calculation of Slant Range From Total Travel Time, W. Vanderkulk, *U. S. Navy Journal of Underwater Acoustics*, **12**, No. 3, 644-648 (July, 1962).

In such maritime operations as acoustic navigation, tracking or location of hydrophones, it is necessary to calculate the slant range from an acoustic source to a receiver from a measured total travel time. This computation can be made (with known velocity profile) by the somewhat cumbersome and time-consuming methods of ray tracing.

The present paper gives a simple but accurate approximate expression for the computation, along with estimates of the

errors incurred in using it. The derivation is a generalization (for arbitrary depth-varying velocity profile) of the special case, derived by A. H. Lubell, for constant velocity gradient.

Carry-Select Adder, O. J. Bedrij, *IRE Transactions on Electronic Computers*, **EC-11**, No. 3, 340-346 (June, 1962).

A large, extremely fast digital adder with sum selection and multiple-radix carry is described. Boolean expressions for the operation are included. The amount of hardware and the logical delay for a 100-bit ripple-carry adder and a carry-select adder are compared.

The adder system described increases the speed of the addition process by reducing the carry-propagation time to a minimum, commensurate with economical circuit design. The problem of carry-propagation delay is overcome by independently generating multiple-radix carries and using these carries to select between simultaneously generated sums.

In this adder system, the addend and augend are divided into subaddend and subaugend sections that are added twice to produce two subsums. One addition is done with a carry digit forced into each section, and the other addition combines the operands without the forced carry digit. The selection of the correct, or true, subsum from each of the adder sections depends upon whether or not there actually is a carry into that adder section.

Characteristics of a High-Speed Multipath Core for a Coincident-Current Memory, E. C. Leaycraft, *IRE Transactions on Electronic Computers*, **EC-11**, No. 3, 405-409 (June, 1962).

Design factors and operational features of a multi-aperture ferrite memory core are discussed showing how a low coercive force, low switching coefficient material may be used for a high-speed coincident current storage device. The formulation, geometry, and important processing variables are given and a method of handling large numbers of asymmetrical cores for electrical test is described. Electromagnetic characteristics, pulse drive and bias test conditions are given. Data are presented showing the effect on core responses of varying net drive, pulse duration, half-select drive and temperature. This device represents about a four-fold speed increase in comparison with present coincident current toroids.

Communication Networks with Simultaneous Flow Requirements, D. T. Tang, *IRE Transactions of the Professional Group on Circuit Theory*, **CT-9**, No. 2, 176-182 (June, 1962).

This paper considers the analysis and synthesis of communication networks with constant branch capacities subject to a set of simultaneous flow requirements which are, in general, time-varying. A set of necessary and sufficient conditions for a communication network to satisfy a given set of simultaneous time-dependent flow requirements is obtained. A synthesis procedure is then derived which enables one to obtain a communication network realization of minimum total branch capacity subject to the constraint that the network must assume a tree configuration.

Critical Fields of Thin Superconducting Films: I. Thickness Effects, A. M. Toxen, *The Physical Review*, **127**, No. 2, 382 (July, 1962).

A theoretical model is presented with which the critical magnetic fields of thin superconducting films can be calculated from any theory of superconductivity for which the kernel of the current-vector potential relationship is known. The model is worked out in detail for the nonlocal theory of Pippard with specular boundary conditions, and the critical field is shown to be a function of film thickness and the nonlocal parameters ξ and $\xi_0\lambda_L^2$. The results are compared to critical-field data for pure indium films and are found to predict very well the observed thickness dependence of critical field. On the basis of reasonable assumptions, ξ_0 and $\lambda_L(0)$ are calculated from the indium critical field data to be 2600 ± 400 Å and 350 ± 100 Å, respectively.

On the Definition of an Infinitely-Many-Valued Predicate Calculus, J. D. Rutledge, *Journal of Symbolic Logic*, **25**, No. 3, 212-216 (September, 1960).

This paper presents a class of plausible definitions for validity of formulas in the infinitely-many-valued extension of the Lukasiewicz predicate calculus, and shows that all of them are equivalent.

Degradation Mechanisms in Germanium p-n-p Transistors, H. R. Wilson, *Semiconductor Products*, **5**, Nos. 6 and 7, 25-29 (Part 1—June, 1962), 18-20 (Part 2—July, 1962).

This study indicates that surface effects are the major contributor to transistor parameter degradation. The most important indicators of physical changes are small signal-current gain, junction-leakage current, and base-spreading resistance. The results also indicate that power dissipation life testing is more severe than temperature storage.

The Dember Effect in ZnS-Type Materials, F. F. Morehead and A. B. Fowler, *Journal of the Electrochemical Society*, **109**, No. 8, 688-695 (August, 1962).

A convenient system is described for measuring the diffusion current pulse produced by the sudden incidence of strongly absorbed radiation (Dember effect) on powder materials of the ZnS type. A model adequately representing the physics of the effect is given. It is shown that it is desirable to eliminate d-c contact effects in order to obtain reliable and reproducible results. The sign of the Dember current pulse indicates the sign of the more mobile carrier when the incident radiation is in the strongly absorbed, fundamental region. Reversals in the sign of the pulse are often encountered for weakly absorbed, longer wavelengths and are attributed to the effect of fast surface states. The excitation spectra for the Dember effect, photoluminescence, and electrophotoluminescence in a ZnS phosphor are given and correlated.

Density Oscillations Between Lanes of a Multilane Highway, D. C. Gazis, R. Herman* and G. H. Weiss,** *Operations Research*, **10**, 658-667 (September-October, 1962).

The interchange of traffic density between lanes moving in the same direction is investigated on the basis of a simple

mathematical model. Emphasis is placed on the question of stability, i.e., attenuation of disturbances from an equilibrium density distribution. A solution is obtained for a system of differential difference equations with a time lag corresponding to the interaction of two lanes. This solution is directly applicable to other problems described by similar equations, such as the follow-the-leader problem. The solution is generalized to n lanes, and it is found that the inherent instability is twice as great for n approaching infinity as it is for two lanes.

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Depletion Layer Properties in Double Diffused Transistors, D. P. Kennedy and R. R. O'Brien, *Journal of Electronics and Control*, **11**, No. 4, 303-315 (October, 1961).

For the double diffused transistor, Poisson's equation is solved in one dimension; this solution is used to determine depletion layer properties of its collector and emitter junctions. Assuming an impurity atom distribution characterized by the summation of complementary error functions, depletion layer widths are established for the equilibrium emitter junction and for the reverse biased collector junction. Applications of this analysis are presented throughout a wide range of physical and geometrical parameters; graphical illustrations are given for the electrical base width, the collector "punch-through" voltage, and others.

Designing Transistor-Biasing Networks for Thermal Stability, R. A. Jensen, *Electronic Design*, **10**, No. 3, 32-35 (February, 1962).

Temperature stability can be designed into transistor-biasing circuitry, while preserving the current gain. Based on a collector-leakage current-reduction factor D , the method is applicable to various biasing circuits.

Determining Seal Quality as a Key to Semiconductor Device Reliability, W. E. Dunkel, *Semiconductor Reliability* (from Conference on Reliability Assurance Techniques for Semiconductor Specifications, October 25-26, 1961 in Washington, D. C.), Engineering Publishers, Elizabeth, New Jersey, 1962, Vol. 2, pp. 211-229.

Bombing methods used for leak detection utilizing either helium or krypton 85 are discussed. The lack of correlation with water entrance, as observed during high humidity life testing, is explained from data obtained with tagged water by the Bendix time-of-flight mass spectrometer. The necessity for good encapsulation is shown by minority carrier lifetime and $V-I$ characteristics as influenced by water.

The Diagnosis of Asynchronous Sequential Switching Systems, S. Seshu and D. N. Freeman, *IRE Transactions on Electronic Computers*, **EC-11**, No. 4, 459-465 (August, 1962).

This paper considers the problem of automatically testing a sequential switching circuit. It is assumed that the sequential circuit is non-clocked in order that the same automatic tester may be used for a wide class of circuits. The program for the tester is to be generated by an IBM 7090 from the

logical description of the circuit to be tested. The problem considered is to write a program for the 7090 to accomplish this purpose. A method of solution, a brief description of the program and an example are given.

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Differential Eyelid Conditioning as a Function of the CS-UCS Interval,* Thomas F. Hartman and David A. Grant,** *Journal of Experimental Psychology*, **64**, 131-136 (August, 1962).

Differential eyelid conditioning was studied at four CS-UCS intervals, 400, 600, 800, and 1000 msec with 20 Ss in each interval. Conditioned discrimination increased as the CS-UCS interval was increased. For Ss who never or rarely showed the voluntary form of eyelid response (Cs) the amount of conditioning to the positive stimulus showed the conventional optimum at about 600 msec CS-UCS interval or less. The increased discrimination was caused by rapid decrease in the percentage of responses to the negative stimulus as the CS-UCS interval was extended. There were indications of optimum discrimination in the Cs at about the 800 msec CS-UCS interval, but the difference between responsiveness to the positive and negative stimulus increased progressively over the CS-UCS range studied for Ss who showed the voluntary response form (Vs).

* Work performed at The University of Wisconsin.

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Direct Examination of Ceramic Surfaces with the Scanning Electron Microscope,* R. F. M. Thornley and L. Cartz,** *Journal of American Ceramic Society*, **45**, No. 9, 425-428 (September, 1962).

A direct electron-optical method of observing an insulator surface is described and applied to a series of alumina ceramics. The surface of the object requires no previous treatment of any kind, and a resolving power of 2000 Å has been obtained with a depth of focus of about 50 μ. Different phases and components can be distinguished. Fractured surfaces, a fault region, and polished surfaces of various alumina ceramics are examined.

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The Discovery of a Simple Cubic Antiferromagnet: Antiferromagnetic Resonance in RbMnF₃, D. T. Teaney, M. J. Freiser and R. W. H. Stevenson,* *Physical Review Letters*, **9**, 212-214 (September, 1962).

Low-temperature microwave resonance measurements have been briefly reported on perovskite XMnF₃ compounds. Of these, the most novel and interesting is RbMnF₃ because it is a cubic antiferromagnet characterized by strong exchange (~10° oe) and small anisotropy (~4 oe). In this letter we report the theory and observation of antiferromagnetic resonance.

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A Dynamic Programming Approach to Sequencing Problems, M. Held and R. M. Karp, *Journal of the Society of Industrial and Applied Mathematics*, **10**, No. 1, 196-210 (March, 1962).

Many interesting and important optimization problems require the determination of a best order of performing a

given set of operations. This paper is concerned with the solution of three such sequencing problems: a scheduling problem involving arbitrary cost functions, the traveling-salesman problem, and an assembly-line balancing problem. Each of these problems has a structure permitting solution by means of recursion schemes of the type associated with dynamic programming. In essence, these recursion schemes permit the problems to be treated in terms of combinations, rather than permutations, of the operations to be performed. The dynamic programming formulations are given, together with a discussion of various extensions such as the inclusion of precedence constraints. In each case the proposed method of solution is computationally effective for problems in a certain limited range. Approximate solutions to larger problems may be obtained by solving sequences of small derived problems, each having the same structure as the original one. This procedure of successive approximations is developed in detail with specific reference to the traveling-salesman problem. Computational experience with an IBM 7090 program using the procedure is summarized.

Dynamic Quantity Information: Input for In-Plant Operational Control, D. B. Thompson, C. T. Baker, A. H. Winchell, J. W. Dammeyer, J. A. Orlicky and R. Roeloffs, *Control Engineering*, **9**, No. 9, 120-133 (September, 1962).

As complete plant operation becomes more automatic, increased amounts of up-to-date information must flow between the plant floor and various levels of management. The procedure involves information accumulation, analysis and response by the production process or management. Much of this information is of the quantity type—measuring or specifying the production rate, total amount and location of processed materials. The benefits that accrue may show up through decreased in-process inventories, but of equal or greater importance are such gains as improved facility and manpower utilization and faster response to product changes. This article looks at manufacturing from a broad viewpoint, considering that quantity information and dynamic quantity control are key segments of more encompassing information and control systems for the operations control of complete plants.

Effect of Crystal Perfection and Polarity of Absorption Edges Seen in Bragg Diffraction, H. Cole and N. R. Stemple, *Journal of Applied Physics*, **33**, 2227-2233 (July, 1962).

When a single crystal is used in an x-ray spectrometer to display the continuous spectrum of an x-ray tube by Bragg diffraction, absorption edges characteristic of the atomic species in the crystal may be observed. The change in diffracted power across an edge is fundamentally due to a change in the atomic scattering, especially the imaginary part of the scattering, of the species whose edge it is. This produces a sharp anomaly in both the structure factor and the absorption factor of the reflection being used. The explicit effect of the absorption is a function of the perfection of the crystal face; the change in the structure factor depends uniquely on (hkl) for noncentrosymmetric crystals. Thus, the absorption edges may be used as a tool to study perfection of the crystal faces and polarity of polar axes. The K edges of Ga and As seen in reflection from (111) and ($\bar{1}\bar{1}\bar{1}$) faces of perfect and mosaic crystals of GaAs are discussed both theoretically and experimentally in some detail. The linear absorption coefficients of GaAs and Ge have been measured in the course of the work.

Effect of Fan Wheel Construction on Sound Pressure Level, K. V. Bostwick, J. R. Engstrom and R. E. Wise, *Sound*, 1, No. 4, 40-42 (July-August, 1962).

The impeller of a squirrel-cage blower was changed to one which replaces the spokes between the vanes and hub with a solid supporting member in the center. Harmonics of the motor rotational frequency generated by the spokes passing the cut-off point of the scroll were eliminated.

Effective Scattering Cross Sections in Scattering Experiments,* K. Berkling, R. Helbing,** K. Kramer,** H. Pauly,** Ch. Schlier** and P. Toschek,** *Zeitschrift fuer Physik*, 166, 406-428 (1962).

Scattering experiments, for instance molecular beam scattering experiments, are often not performed with monochromatic beam and target particles at rest. Two arrangements are normally employed, one using a gas chamber as target, the other using a crossing beam. In both cases the scattering particles have a Maxwellian velocity distribution. Hence an *effective cross section* is measured, which is an integral over cross sections for different collision velocities. Other similar integrals are needed in dealing with polarized beams and angular dependent cross sections. A third type of integral is required, if the primary beam is not monochromatized. The functions needed to interpret the scattering experiments mentioned are given in this paper, as well as a table of values for these functions.

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Electrons and Holes in Bismuth, A. L. Jain and S. H. Koenig, *The Physical Review*, 127, 442-446 (July, 1962).

We have re-examined the data published to date that give information (1) on the carrier density per (electron or hole) ellipsoid and (2) on the total carrier density in bismuth at helium temperatures. We show that, in contradiction to some recent conjectures, the number of electron ellipsoids is three; the number of light-hole ellipsoids, one. The uncertainty in this analysis allows for the possible existence of heavy holes with a number density no greater than $\sim 15\%$ of the light-hole density, assuming that there are no heavy electrons.

Energy Dependence of Indirect Optical Absorption in Semiconductors, R. L. Hartman, *The Physical Review*, 127, No. 3, 765-767 (August, 1962).

Formulas are obtained for the indirect absorption coefficient as a function of photon energy, for both degenerate and nondegenerate semiconductors, taking into account the dependence of the energy denominator on the energy of the intermediate states. The light-hole and heavy-hole contributions and the total absorption were computed for germanium. The results are displayed as a function of photon energy, in graphs, for the nondegenerate case and for several Fermi energies. The results show that, for degenerate material, absorption edges obtained by extrapolation of the experimental absorption spectrum are liable to be too low.

Evaluation of Molecular Integrals by Solid Spherical Harmonic Expansions,* R. M. Pitzer,** C. W. Kern and W. N. Lipscomb,** *The Journal of Chemical Physics*, 37, No. 2, 267-274 (July, 1962).

The use of expansions of solid spherical harmonics, which are the functions $(r^n \text{ or } r^{n-1}) P_n^m(\cos \theta)$ ($\cos m\phi$ or $\sin m\phi$), is discussed with respect to molecular integrals, and it is found that terms of the delta function type must be included in the expansion for the r^{n-1} case if $n-m \geq 2$. These expansions are especially useful for operators involving inverse powers of r such as electromagnetic interaction operators. General formulas are given for integrals in which two atomic orbitals, e.g., Slater orbitals, are on one center, and one of these operators is on the other center. Formulas are also given for the corresponding one-center integrals, and methods of evaluating three-center integrals and other two-center integrals are discussed briefly.

* Work done while at Harvard University.

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Experiments on the End Effect in Dual Material Columns, E. C. H. Becker and H. D. Conway, *Journal of Applied Mechanics*, 29, No. 3, 586-587 (September, 1962).

Compression experiments were made on columns formed from two circular cylinders of equal size with their flat ends in contact. From measurements of the diameters at various sections at and away from the junction, a measure of the end effect was obtained. The experiments were carried out on steel and brass cylinders in contact with one another, and with several diameters and contact surface conditions. It was observed that the end effect with sand-blasted or physically joined ends disappeared after approximately two-thirds of a diameter, irrespective of the diameter. They could easily be reduced to one-third of a diameter by smoothing and lubricating the contact surfaces.

The Extensive Power of Information Processing in Nature and Mind, H. Zemanek, *Süddeutsche Zeitung*, 4, 208 (1962).

Information is a combination of sign; the atom of information is the bit, the decision between two possibilities. Languages, therefore, are a basic tool for the organization of electronic automata. But also nature applies coding and logical processing of information. Repetition is in all cases essential for automatism and learning procedures. Automatic reproduction in nature is a challenge for science. The automaton is the culmination of science.

Fatigue Testing of Thin Tapes, H. Pih and A. T. Shalkey, *Experimental Mechanics*, 2, No. 7, 211-215 (July, 1962).

A fatigue-testing machine is described which was designed for one-way bending. The bending load is obtained by forcing the tape to conform to a set of 18 rollers of a given diameter arranged in a "squirrel cage" fashion. A different stress level, for a given tape thickness, is obtained by replacing the entire set of rollers of a different diameter. The device is operated at 667 rpm in this study, giving cyclic one-way bending at a rate of 12,000 cpm. The fatigue life of each tape is recorded by a time-counter unit controlled

by a relay circuit. Tape specimens used in this investigation were 0.0003 in thick and 0.200 in wide. Four specimens were used in each run. Mathematical analyses for deflection and boundary conditions are given, along with an illustration of the device and operating techniques employed.

Ferromagnetism in Divalent Europium Salts, T. R. McGuire, B. E. Argyle, M. W. Shafer and J. S. Smart, *Applied Physics Letters* **1**, 17 (1962).

The sequence of divalent europium compounds EuO, EuS, EuSe and EuTe all have the NaCl structure, and EuO has been found to be ferromagnetic by Matthias, Bozorth, and Van Vleck. We have prepared the other three compounds and have found that the sulfide and selenide are ferromagnetic with transition temperatures of about 18° and 8°K, respectively. The telluride is paramagnetic (possibly antiferromagnetic) at 4.2°K. The saturation magnetization of the sulfide is 6.8 μ_B per Eu⁺⁺ ion, in good agreement with the expected value of 7.0 μ_B ; the magnetization of the selenide has not been determined very accurately, because of impurities in the sample, but it seems consistent with 7 μ_B per Eu⁺⁺ ion.

Flux Reversal in Square Loop Ferrite Cores,* R. F. Elfant and F. J. Friedlaender,** *Journal of the Physical Society of Japan*, **17**, Supplement B-1, 640-43 (March, 1962).

The flux reversal mechanisms for Mg-Mn ferrite cores are reviewed and the double pulse experiment is introduced, to select the valid model. On the basis of experimental results, it is shown that the model of domain wall motion is not adequate to explain the flux reversal process for a large range of values of the applied field. However, the model consisting of domain wall motion of low values, incoherent rotation for intermediate values, and coherent rotation of large values of the applied field explains the experimental results adequately.

Using a modification of Haynes's model of domain wall motion, a procedure is outlined to determine β , the Goodenough and Menyuk damping constant. From β it is possible to find α , the modified Landau-Lifshitz damping constant. Using α , the switching constants for domain wall motion and rotation are calculated. A comparison of the experimental and calculated switching constants is given and discussed.

* Work performed at Purdue University and supported in part by the National Science Foundation.
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General Potential-Energy Function for Exchange Reactions,* F. T. Wall** and R. N. Porter, *The Journal of Chemical Physics*, **36**, No. 12, 3256-3260 (June, 1962).

A general potential-energy function for linear triatomic systems has been developed for use in connection with reaction kinetics calculations. The function is a generalization of the Morse function with a sufficient number of adjustable parameters to permit arbitrary fixing of the location and curvatures of the saddle point of the potential energy surface. The function reduces, of course, to the Morse function when one of the atoms is infinitely distant from the other two. Since the characteristics of the saddle region are adjustable, the function is particularly useful in connection with computations designed to test the effect of different

shapes of potential energy surfaces upon reaction probabilities. The function is most readily used for symmetric reactions, but it can be further generalized to cover unsymmetric cases.

* Work done while at University of Illinois.
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A Generalization of the Gamma Distribution, E. W. Stacy, *The Annals of Mathematical Statistics*, **33**, No. 3, 1187-1192 (September, 1962).

This paper describes a generalization of the gamma probability distribution. In essence, the generalization is accomplished by introducing a shape parameter whose value is positive. The resulting frequency function is defined as $f(x; a, d, p) = (p/a^d) x^{d-1} e^{-(x/a)^p} \Gamma(d/p)$, for non-negative values of x and positive values of the parameters. Special cases of this function describe frequencies for the familiar chi-squared, exponential, Weibull, and gamma variates. It happens also that the modulus of a standard normal variate has a frequency function of this form, and so do all positive powers of such a modulus. The moment generating function is shown in the paper, and a means is provided for deriving exact values of cumulative probabilities—using tables of the incomplete gamma function. Distributions are given for positive powers of a generalized gamma variate and for various functions of independent generalized gamma variates. Special attention is given to the distribution of the sum of such variates. Convolution results occur in alternating series, with coefficients whose evaluation may be tedious and lengthy. An upper bound is provided for the modulus of each term, and simplified term-by-term computation methods are developed for some special cases. In addition, it is shown that certain studies concerning the distribution of a definite quadratic form apply to a larger class of problems than was previously realized. Methods used in those studies are extended to derive iterative formulae for the coefficient in convolution results given in the paper.

Some Geometrical Considerations for X-Ray Collimation in Single-Crystal Diffraction Work, H. Cole, F. W. Chambers and C. G. Wood, *The Review of Scientific Instruments*, **33**, 435-437 (April, 1962).

In positioning an x-ray tube in an experiment to gain optimum usable power, the variables at the operator's control are the take-off angle and the collimation (or slit) system. These variables should be fixed by consideration of sample size, focal-spot size, target absorption shadow, and the amount of divergence to be permitted. Consideration of these factors leads to an uncommon collimator for simple large single-crystal diffraction work.

Gimbal Goniometer, H. Cole and M. Okrasinski, *The Review of Scientific Instruments*, **33**, 942-943 (September, 1962).

A goniometer for single-crystal diffraction work, based on the use of a gimbal system, is described. The gimbal is driven by the rolling of a spherical section in frictional contact with a movable plane. The special features of the device are discussed.

A Harmonic Analysis of Saturation Recording in a Magnetic Medium, B. Kostyshyn, *IRE Transactions on Electronic Computers*, **EC-11**, No. 2, 253-262 (April, 1962).

A single write-read head coupled with saturation recording techniques is commonly used to store digital information. Because of the experimental difficulty in determining the contribution of individual parameters to the system, a theoretical equation describing the output of a system in terms of the physical, magnetic, and electrical parameters of the system has been developed and programmed for the IBM 704.

When applied to an experimental NRZ system, excellent agreement between observed and calculated results was obtained. The phenomena of peak or phase shift and amplitude shift occurring for an isolated pair of adjacent ONES at high bit densities is demonstrated and discussed. The calculated dependence of the zero-to-peak output and the peak-and-amplitude shifts is shown for variations in the thickness, retentivity, coercivity and squareness of the storage medium, and for variations in the write current, the head-to-medium spacing, and the pole gap dimensions.

The Heat Capacity of Cuprous Oxide from 2.8° to 21°K,* L. V. Gregor, *Journal of Physical Chemistry*, **66**, 1645-1647 (September, 1962).

The heat capacity of Cu_2O has been measured from 2.8° to 21°K. Although no anomalous peaks are observed, there are similarities below 15°K to the heat capacity of highly annealed Ag_2O , which is isostructural to Cu_2O . The observed heat capacity is lower than predicted by a Debye extrapolation from data above 14°K, and a revised value of $22.25 \pm 0.05 \text{ cal deg}^{-1} \text{ mole}^{-1}$ obtained for $S^{298.15}$.

* Work performed at the Lawrence Radiation Laboratory, University of California.

Heat Transfer from a Cylinder to a Power-Law Non-Newtonian Fluid, M. J. Shah, E. E. Petersen,* and A. Acrivos,** *American Institute of Chemical Engineers Journal*, **8**, 542-549 (September, 1962).

Heat transfer from a uniformly heated cylinder to a power-law non-Newtonian fluid has been studied in a water tunnel with a dilute solution of carboxymethyl cellulose (CMC) in water. The experiments were restricted to CMC solutions which follow the power law and which, to all appearances, do not show viscoelastic effects. The experiments were performed under laminar boundary-layer flow conditions with the axis of the cylinder normal to the flow. Experimentally measured temperature distributions at the surface of the cylinder are compared with the results of a theoretical analysis which only requires, for each fluid, the independent evaluation of the rheological parameters of the power law.

* University of California.

** Stanford University.

On a Hilbert Space with Nonassociative Scalars, H. H. Goldstine and L. P. Horwitz, *Proceedings of the National Academy of Sciences*, **48**, 1134-1142 (July, 1962).

Some properties of a Hilbert Space in which Cayley numbers are admitted as multipliers are discussed. The paper culminates with the usual spectral resolution for a bounded Hermitian operator and its application to the derivation of

a theorem relating to some geometrical properties of a special class of hypercomplex operators. A connection between these operators and the structure of the Hilbert Space is established.

Hyperfine Structure of the 3P States of Zn^{67} and Mg^{25} , Allen Lurio, *The Physical Review*, **126**, No. 5, 1768-1773 (June, 1962).

The hyperfine structure of the metastable $(4s4p) ^3P_2$ state of Zn^{67} and the metastable $(3s3p) ^3P_2$ and 3P_1 states of Mg^{25} have been measured by the atomic beam magnetic-resonance technique. The magnetic dipole and electric quadrupole-coupling constants obtained from these measurements are: $\text{Zn}^{67}(^3P_2)$, $A=531.987 \pm 0.005 \text{ Mc/sec}$, $B=35.806 \pm 0.005 \text{ Mc/sec}$; $\text{Mg}^{25}(^3P_2)$, $A=-128.445 \pm 0.005 \text{ Mc/sec}$, $B=16.009 \pm 0.005 \text{ Mc/sec}$; $\text{Mg}^{25}(^3P_1)$, $A=-144.977 \pm 0.005 \text{ Mc/sec}$, $B=-8.308 \pm 0.005 \text{ Mc/sec}$. These results are compared in detail with the Breit-Wills and Casimir theory of two-electron hyperfine structure. The electric quadrupole moments of these nuclei are found to be: $Q(\text{Zn}^{67})=0.16 \times 10^{-24} \text{ cm}^2$, $Q(\text{Mg}^{25})=0.22 \times 10^{-24} \text{ cm}^2$. The quadrupole moment of Mg^{25} is shown to be in very good agreement with that value obtained from other experiments through the use of the collective model in strong couplings. The detection of a beam of metastable 3P_1 Mg atoms places a lower limit on the lifetime of this state of about 10^{-8} sec .

Identification of the Urethane-Epoxy Reaction Product, R. N. Wood, *Society of Plastics Engineers Transactions*, **2**, 193-201 (July, 1962).

The probable molecular structure resulting from a reaction of equal parts of a Bisphenol A/Epichlorohydrin epoxy and a tolylene diisocyanate prepolymer with a selected diamine has been identified by using infrared spectrometry. This identification presents additional opportunities for attaching other complex molecules to either of the basic resins. This technique not only leads to an interesting family of hybrid plastics, but also is another step toward designing specific molecules for specific applications.

Infrared Lattice Bands in AlSb, W. J. Turner and W. E. Reese, *The Physical Review*, **127**, No. 1, 126-131 (July, 1962).

Lattice bands in AlSb involving interactions of infrared radiation with one, two, three, and four phonons have been observed between 8 and 38μ . The multiphonon combination bands (summation or difference) can be explained in terms of four characteristic phonons at or near the zone boundary. The corresponding phonon wave numbers are 316, 297, 132, and 65 cm^{-1} . The interaction of infrared radiation with the transverse optical phonon at the center of the zone results in a single-phonon absorption band and the Reststrahlen reflectivity band. The reflectivity data can be fitted to simple dispersion theory. The fundamental optical frequency from this fit is $(9.564 \pm 0.019) \times 10^{12} \text{ sec}^{-1}$ (319 cm^{-1}). The index of refraction n and extinction coefficient k were calculated as functions of wavelength between 20 and 38μ using dispersion theory.

Interband Transitions and Maser Action, W. P. Dumke, *The Physical Review*, **127**, No. 5, 1559-1563 (September, 1962).

The possibility of using interband transition to achieve maser action is considered. The criterion for maser action

is presented in a way which allows the most direct use of optical absorption data. The absorption constant for interband transitions, which is negative (corresponding to induced emission when a population exists), is related to the normal absorption constant for direct, indirect, and indirect exciton transitions. Using available absorption data, it is shown that in Ge maser action, using either the indirect or indirect exciton transitions would be prevented by absorption due to free carriers. In GaAs or other materials with a direct band gap, however, it is entirely possible that maser action could be achieved.

Isothermal Squeeze Films, W. E. Langlois, *Quarterly of Applied Mathematics*, **20**, No. 2, 131-150 (July, 1962).

A derivation is presented of the equation governing the pressure in a thin, flat film of ideal gas under isothermal conditions, where the surfaces bounding the film are in relative normal and tangential motion. When tangential motion is absent, the pressure equation reduces to a nonlinear heat equation, which admits of very few closed-form solutions. Various approximation methods are discussed, and two problems involving small periodic variation of the gap between parallel plates are solved by a perturbation method for a film in which fluid inertia is negligible.

Low Temperature Thermal Conductivity of Amorphous Solids, G K. Chang and R. E. Jones, *The Physical Review*, **126**, 2055-2058 (June, 1962).

The thermal conductivities of five samples of commercial glasses and glass ceramics were measured at liquid helium temperatures. It was found that the conductivity data could be accounted for by an intrinsic structure scattering of phonons as proposed by Klemens, combined with an internal boundary scattering. The intrinsic structure scattering of these specimens was less than that calculated by Klemens using Berman's data for vitreous quartz. The mean free path calculated for scattering at internal boundaries was of the order of 10^{-2} to 10^{-3} cm.

Machine Properties Preserved under State Minimization, C. C. Elgot and J. D. Rutledge, *Switching Circuit Theory and Logical Design*, Proceedings of the Third Annual AIEE Symposium, 61-70 (September, 1962).

Most of the published material concerning "state minimization of incompletely specified machines" has been concerned with finding an algorithm which yields a minimum state machine M^1 , which satisfies a given machine M . A fundamental theorem in this connection is given elsewhere. We are concerned here primarily with properties which some or all machines M^1 inherit from M .

Magnetic Properties of Thin Films Evaporated in Ultra-high Vacuum, A. Methfessel, A. Segmüller and R. Sommerhalder, *Journal of the Physical Society of Japan*, **17**, Supplement B-I, 575-579 (1962).

A NiFe alloy with 80% Ni was evaporated onto heated, polished substrates in a vacuum of 10^{-9} mm Hg and in a technical system of 10^{-5} mm Hg. Comparison of the properties of both film types proves the influence of the residual gas on both the wall motion coercive force H_c and the anisotropy field of strength H_K . H_c is interpreted as being determined by two contributions: First, a roughness part with

small temperature dependence and second, an impurity part with the same temperature dependence as reported for bulk material. The temperature dependence and the annealing behavior of H_K in films evaporated in ultra-high vacuum are identical to those of bulk alloys. Films produced in the technical system have an additional gas-induced anisotropy which can be changed reversibly by low temperature annealing.

Magnetic Shielding in Some Diatomic Molecules,* C. W. Kern and W. N. Lipscomb,** *The Journal of Chemical Physics*, **37**, No. 2, 260-266 (July, 1962).

Magnetic shielding constants calculated for all nuclei in LiH, BH, NH, BF, HF, LiF, CO, H₂, Li₂, N₂ and F₂ have yielded good results for lighter nuclei bonded to heavier nuclei. The difficult paramagnetic contribution of Ramsey's theory is reduced to tractable terms involving only the ground-state wave function by a choice of the gauge of the vector potential, and by an approximation involving cancellation of average excitation energies of matrix elements depending upon angular momentum and linear momentum operators. The limitations of this approximation are explored.

* Work done while at Harvard University.

** Harvard University.

Magnetocrystalline Anisotropy of W-Type Hexagonal Barium-Cobalt-Iron Oxides, L. R. Bickford, Jr., *Journal of the Physical Society of Japan* (Proceedings of International Conference on Magnetism and Crystallography, Sept., 1961), **17**, Supplement B-I, 272-275 (March, 1962).

The magnetocrystalline anisotropy of cobalt-iron, W-type hexagonal oxides ($\text{BaCo}_y\text{Fe}_{1-y}\text{O}_{10}$) is investigated over the temperature range from 77° to 500°K by the torque method. The materials with intermediate cobalt concentration ($0.4 < y < 1.0$) display cones of easy magnetization at some temperatures. The sample $y = 0.9$ shows the unusual behavior of the preferred direction changing from axis to cone to plane to cone as temperature decreases. All torque curves are well fitted by an anisotropy expression which consists of three terms of a series expansion in spherical harmonics. Each of the coefficients in the expansion is found to be linear in y . The values of each of the coefficients are found to be consistent with Slonczewski's theory of cobalt ion anisotropy throughout the observed ranges of temperature and composition.

Manufacturing Progress Function Nomograph, P. B. Metz, *Journal of Industrial Engineering*, **13**, No. 4, 253-256 (July-August, 1962).

The Manufacturing Progress Function, or cost-quality relationship, has gained considerable impetus as an important tool in cost estimating. The computations involved in applying the MPF are rather involved and laborious. The MPF nomograph has been designed to alleviate this problem; in conjunction with a few basic arithmetic computations, it is capable of solving MPF applications with an accuracy in excess of 99%.

Measuring of the Van der Waals-Force Anisotropy,* K. Berkling, Ch. Schlier** and P. Toschek,** *Zeitschrift fuer Physik*, **168**, 81-102 (1962).

Van der Waals forces between two atoms (none in S-state) have no spherical symmetry. We report on an experiment

which verifies this anisotropy by measuring it. The experiment consists of comparing the total scattering cross sections of Ga atoms in selected magnetic substates $m_j = 1/2$ and $3/2$ of the upper ($^2P_{3/2}$) level of the ground state doublet of Ga. Rare gases are used as scatterers. The relative total cross section difference in units of 10^{-4} is 94.9 ± 4.3 for Xe, 79.4 ± 6.6 for Ar, and 195 ± 5 for He as the scattering gas. The apparatus uses an atomic beam with magnetic selection, common geometry, and a common detecting scheme for both states, which are compared in short intervals by merely switching the selecting magnets' current. Theoretical estimates are in rough agreement with experiments. Errors are discussed.

* Work performed at Physikalisches Institut der Universität Bonn, Germany.

** Physikalisches Institut der Universität Bonn, Germany.

Mechanized Information Processing and the Librarian, H. S. White, *Canadian Library* (The Bulletin of the Canadian Library Association), **19**, No. 2, 64-69 (September, 1962).

Mechanization of library systems has suffered from lack of communication between the librarian and the systems engineer. Properly conceived and installed, such systems help the librarian by freeing him from repetitive clerical duties, by permitting him to offer a higher level of information service, and by enhancing his professional status. Librarians should begin by mechanizing their processing routines, and proceed to the justification of computer information retrieval through the use of a building-block approach.

Message Compression, H. Blasbalg and R. Van Blerkom, *IRE Transactions on Space Electronics and Telemetry*, **SET-8**, 228-238 (September, 1962).

Two general classes of operations for the purpose of compressing the output of a message source are considered: (1) entropy-reducing (ER) transformation, and (2) information-preserving (IP) transformation (redundancy removal). The type (1) transformation, when acceptable, can yield substantial compression gains in telemetry applications while the type (2) transformation can yield substantial gains for certain types of source statistics. A new concept, adaptive coding, is introduced. It is shown that for quasi-stationary source statistics it is possible to obtain estimates of the statistics and to use these subsequently for efficient coding. A general statistical measure for monitoring the efficiency of the adaptive procedure is presented and a decision rule, based on this statistic, for updating the coding is defined. It is shown that the statistical estimates need not be precise since the coding efficiency remains reasonably insensitive to small errors; hence, only violent changes in the source statistics must be detected.

Methods of Mechanical Language Translation, H. Zemanek, *Sprache im Technischen Zeitalter*, **2**, 87-110 (1962).

After an introduction to methods of automation, the basic structure of translating programs is outlined. The electronic dictionary and a few examples of translating procedures are given. Probabilistic possibilities are mentioned. A translation example of the IBM system is given. Thirty-two research groups are listed and very briefly characterized.

Multiple Reaction Vapor Transport of Solids, R. F. Lever, *The Journal of Chemical Physics*, **37**, No. 5, 1078-1081 (1962).

A model is developed for one-dimensional steady-state diffusion-limited transport of solid in the presence of several chemical equilibria. The assumption that all the binary diffusion coefficients may be considered equal enables the flow to be expressed very simply in terms of the diffusion coefficient and a simple parameter describing the over-all gas composition, without reference to individual molecular species. Thermal diffusion is neglected.

Multiple Reactions and the Vapor Transport of Solids, G. Mandel, *The Journal of Chemical Physics*, **37**, No. 6, 1177-80 (1962).

The method of Lever, which has enabled calculation of the steady-state diffusion-limited rate of transport of solid for the case of a single chemical equilibrium, is generalized to include the situation in which several equilibria are simultaneously operating. This is accomplished for the case of N equilibria by the introduction of $(N-1)$ coupling parameters, so defined that the steady-state conditions become formally identical to those given previously. Following Lever, the results of these operations are combined with the usual thermodynamic relations for the temperature dependence of the equilibrium constants, finally resulting in a set of $(N-1)$ linear simultaneous equations in $(N-1)$ unknowns, the coupling parameters. These equations can be solved, in general, in terms of the ratios of $(N-1)$ dimensional determinants.

On the basis of the above, a straightforward procedure is devised for the calculation of the rate of transport of solid, based on knowledge of initial conditions as well as thermodynamic and diffusion coefficient data.

Multivariate Analysis in Psychology and Education, R. E. Bargmann, *Bulletin de l'Institut International de Statistique*, **38**, Part 4, 79-86 (1961).

A brief survey is made of multivariate analysis techniques used in the social sciences. Application of classical methods, dependence analysis, and model construction are the main topics of this paper.

The Nature and Behavior of Electrostatic Images, R. M. Schaffert, *Photographic Science and Engineering*, **6**, 197-215 (July-August, 1962).

Treatment of electrostatic images as sinusoidal charge patterns of varying spatial frequencies provides a convenient method of computing electrical potentials and fields associated with these images. It is shown that field intensity varies with spatial frequency and has a peak value in the range of 7 to 12 lines/mm. A development electrode increases the intensity of the image field, and this effect is enhanced as the electrode is brought closer to the image. When the electrode spacing is equal to the thickness of the photoconductive layer, the field intensity and field contrast at the image surface are constant for all spatial frequencies. The implications of these factors in electrostatic image development are discussed.

A New Class of Multilayer Series-Coupled Perceptrons, A. G. Konheim, *Proceedings of the Conference on Self-Organizing Systems*, 485-502 (September, 1962).

A general treatment of multilayer networks of threshold elements is presented in this paper. Geometric conditions which imply the convergence of the "learning" procedure are obtained.

A New Method for the Determination of the Ferromagnetic Exchange Constant, S. Methfessel, S. Middelhoek and H. Thomas, *Journal of the Physical Society of Japan*, **17**, Supplement B-I, 607-609 (1962).

A new method for the determination of the ferromagnetic exchange constant A is described. It is based on the response of the magnetization to an inhomogeneous magnetic field, which is generated by passing a current through a thin ferromagnetic sample. The theory is given for two cases of a plane film and a cylindrical wire. Preliminary experimental results on a 6600 A permalloy film gave a value of $A = 0.55 \times 10^{-6}$ erg/cm $\pm 10\%$.

A Nonlinear Digital Optimizing Program for Process Control Systems, R. A. Mugele, *Proceedings of the 1962 Spring Joint Computer Conference* (American Federation of Information Processing Societies), **21**, 15-32 (May, 1962).

This paper describes a newly developed program suitable for optimization of a computer-controlled process. The program applies probing and constraint-following algorithms which permit solving the optimization problem in difficult cases. These cases include nonlinear and discontinuous objective functions, constraint functions and nonconvex domains. The program has become known as the "poor man's optimizer," as it requires relatively little storage for program and data. It is applicable to the relatively small digital computers now popular in process control.

Nuclear Quadrupole Resonance of Li in Ferromagnetic Compounds, G. Burns, *The Physical Review*, **127**, 1193 (August, 1962).

Measurements have been made of the temperature dependence of the nuclear quadrupole coupling constant, eQq/h , of Li in a number of ferroelectric compounds. The compounds discussed are $\text{LiNH}_4\text{C}_4\text{H}_4\text{O}_6 \cdot \text{H}_2\text{O}$, $\text{LiTiC}_4\text{H}_4\text{O}_6 \cdot \text{H}_2\text{O}$, LiTaO_3 , LiNbO_3 , and $\text{LiN}_2\text{H}_6\text{SO}_4$. Powdered samples were used in all cases except the first where single crystals were also measured and favorably compared with the powder results.

The Onset of High Magnetic Field Superconductivity, D. P. Seraphim, C. Chiou and R. A. Connell, *Proceedings of VIIIth International Conference on Low Temperature Physics*, London, England, Article 7.18, 309-313 (September 16-22, 1962).

For mean free paths less than 440 ± 100 A, the dc resistance, magnetic susceptibility and low frequency surface impedance data on a series of bulk indium-base alloys (Bi, Pb, Sn, Cd, Tl, Hg) indicates negative interfacial energies between superconducting and normal material. The experi-

ments demonstrate the presence of an intermediate state, normal and superconducting, at magnetic fields much less than H_c as well as the usual filamentary superconductivity at high magnetic fields. Thus quantitatively, the mean free path effect, and qualitatively, the intermediate state effect at low fields, are in agreement with the theory of Abrikosov and Gorkov. Data on severely cold-worked high purity tantalum are compared to the alloying effect. Cold work has only a minor effect in increasing the filamentary critical magnetic field in comparison to the mean free path effects in bulk indium alloys.

Ordering Energy Levels of Interacting Spin Systems, E. Lieb and D. Mattis, *Journal of Mathematical Physics*, **3**, No. 4, 749-751 (July-August, 1962).

The total spin S is a good quantum number in problems of interacting spins. We have shown that for rather general antiferromagnetic or ferrimagnetic Hamiltonians, the lowest energy eigenvalue for each value of S [denoted $E(S)$] is ordered in a natural way. In antiferromagnetism, $E(S+1) > E(S)$, for $S \geq 0$. In ferrimagnetism, $E(S+1) > E(S)$, for $S \geq \mathcal{S}$, where $\mathcal{S}$ is defined as follows. Let the maximum spin of the A sublattice be S_A and of the B sublattice S_B ; then $\mathcal{S} = |S_A - S_B|$. Antiferromagnetism is treated as the special case of $\mathcal{S} = 0$. We also briefly discuss the structure of the lowest eigenfunctions in an external magnetic field.

Oscillating Sort—A New Sort Merging Technique, S. Sobel, *Journal of the Association For Computing Machinery*, **9**, 372-374 (July, 1962).

Oscillating Sort, designed to gain an $(N-1)$ -way merge with N merging tapes available, is further specifically designed for read-backwards tapes, and if read-write overlap is available, for cross-channel switching, i.e., the ability for any tape to be read while any other tape is being written. Furthermore, this technique is compatible with replacement sorting techniques.

Overshoot in Photoconductivity of Lead Oxide,* K. E. Haq, *Journal of Applied Physics*, **33**, 2606-2612 (August, 1962).

The overshoot in the photoconductivity of lead oxide has been studied. It has been concluded to be due to build-up of space charge in the bulk of the material, rather than to any blocking at the electrode. The overshoot vanishes both at temperatures above $+70^\circ\text{C}$ and below -50°C . A physical model, which can explain these results, has been discussed.

* Work performed at General Electric Company, Milwaukee, Wisconsin.

Paramagnetic Resonance Studies of Cr^{3+} in Cubic and Hexagonal ZnS , J. Dieleman,* R. S. Title and W. V. Smith,** *Physics Letters*, **1**, 334 (July, 1962).

A study of optically active paramagnetic centers in cubic and hexagonal ZnS powders and crystals revealed the presence of paramagnetic Cr^{3+} impurities. The resonance is observed both at 300° and 77°K . At 77°K the fine structure is resolved into its components as is the hyperfine structure due to the odd isotope Cr^{53} . The hyperfine structure is independent of the modification of ZnS within the accuracy of the measurements. The value of $g = 1.9995 \pm 0.0005$, the Cr^{53} hyper-

fine structure constant $A=14.3\pm0.1$ oe and the cubic field splitting parameter, determined from measurements on a cubic single crystal, $a=4.2$ oe. The spin-lattice relaxation time is of the order 10^{-6} sec. The chromium may be introduced into the ZnS as Cr^{2+} which requires no charge compensation and is a killer for the luminescence. The Cr^{2+} gives rise to a deep electron trap and may be modified into Cr^{+} by addition of uncompensated shallower donor levels such as A1 and C1 or by irradiation of compensated samples with ultraviolet light.

* Philips Research Laboratories, N.V. Philips' Gloeilampenfabrieken Eindhoven, Netherlands.

** In residence at Philips Research Laboratories, Eindhoven, Netherlands during period of investigation.

Photochemistry of Methoxy Acetone, R. Srinivasan, *Journal of the American Chemical Society*, **84**, 2475 (1962).

Photolysis of methoxy acetone at 3130 Å led to acetone and formaldehyde as the important products. A small amount (about 1/20th of the acetone) of carbon monoxide was the only other significant product. Oxygen had no effect at 105°, but at room temperature a decrease in the yield of acetone was noted. It is believed that acetone (and formaldehyde) are formed by the Norrish type II intramolecular process. The effect of oxygen at room temperature may be due to changes in the surface of the walls of the reaction cell.

Photoisomerization of 1, 3, 5-Cycloheptatriene and its Relation to Internal Conversion of Electronic Energy, R. Srinivasan, *Journal of the American Chemical Society*, **84**, 3432 (1962).

The photolysis of 1, 3, 5-cycloheptatriene in the vapor phase led to the formation of toluene and bicyclo (3.2.0) heptadiene -2, 6. It is suggested that isomerization to toluene occurs not from an electronically excited molecule of cycloheptatriene but from a vibrationally excited ground state molecule that is formed by the internal conversion of the electronic energy. In contrast, the formation of bicycloheptadiene is believed to occur from electronically excited cycloheptatriene.

Precise Critical-Field Measurements of Superconducting Sn Films in the London Limit,* D. H. Douglass, Jr.** and R. H. Blumberg, *The Physical Review*, **127**, No. 6, 2038-2043 (September, 1962).

The original Ginzburg-Landau (GL) theory consists of assumptions concerning the form of the magnetic field and the field-free parts of the free energy. The field-free portion which is derived by expanding in a power series valid only near T_c is nevertheless well behaved at low temperatures. The GL theory can be generalized to include any field-free function (the Gorter-Casimir (GC) free energy expression is one) covering all T , whose expansion near T_c is the same as that of the original theory. The critical field of a thin film can be expressed in terms of this generalized function. The differences between various functions can be expressed in terms of a parameter ϵ which can be measured experimentally at the lower temperatures. Theoretical values of ϵ are $+0.25$ and -0.75 for the GL and the GC functions, respectively. Experimental measurements on thin films of tin give

a value of $\epsilon=0.14\pm0.10$, which seems to favor the original GL theory.

* Work supported in part by the U. S. Army Signal Corps, the Air Force Office of Scientific Research and the Office of Naval Research.

** Work performed while at Massachusetts Institute of Technology. Present address: University of Chicago.

On the Preparation of High Purity Gallium Arsenide, N. G. Ainslie, S. E. Blum and J. F. Woods, *Journal of Applied Physics*, **33**, No. 7, 2391-2393 (July, 1962).

Gallium arsenide of markedly improved electrical properties has been prepared reproducibly by two techniques designed to reduce the level of the donor impurity silicon. Crystals so produced have room temperature mobilities in the 6300 to 8000 $\text{cm}^2 \text{ volt}^{-1} \text{ sec}^{-1}$ range and 77°K mobilities in the 12,000 to 20,000 $\text{cm}^2 \text{ volt}^{-1} \text{ sec}^{-1}$ range.

Grundsätzliches und Grenzabschätzungen betreffend hydrodynamische Verstärker (Principles and limitations of pure fluid amplifiers), H. H. Glaetli, *Zeitschrift für angewandte Mathematik und Physik (ZAMP)* **XIII**, 500-502 (September, 1962).

Three types of hydrodynamic amplifiers are explained: Free jet, vortex chamber, and boundary-layer amplifier. Cavitation effects represent a serious limitation when incompressible fluids are used. A similar limit is given by sonic velocities in the case of compressible fluids. By combining these limits (max. pressure, max. velocity) with the trivial requirement of a certain minimum Reynolds-number, a minimum size and a minimum response time can be established. Some specific values for various fluids as well as the corresponding power requirements are given.

Principles of Logical Information Processing, H. Zemanek, *Elektrotechnik und Maschinenbau*, **79**, 200-208 (1962).

An introduction to Boolean algebra for electrical power engineers is given. Basic notions, operators, procedures and technical realization are indicated. Some remarks are made on bundles of Boolean functions, sequential logical, algebra and probabilistic logic.

Proton Chemical Shift in $\text{HCo}(\text{CO})_4$,* R. M. Stevens,** C. W. Kern and W. N. Lipscomb,** *The Journal of Chemical Physics*, **37**, No. 2, 279-283 (July, 1962).

The anomalous high-field chemical shift observed in general for H bonded to a heavy metal has been calculated in the localized diatomic approximation for the CoH bond in $\text{HCo}(\text{CO})_4$ with the use of the theory of Kern and Lipscomb, valid for a light atom bonded to a heavy atom. It is shown for the first time that reasonable agreement with experiment is obtainable at a bond distance corresponding to a normal covalent bond, and that, aside from the electron around H, the major contribution to the high-field shift comes from the electron populations in the large and diffuse 4s and 4p orbitals of Co.

* Work done while at Harvard University.

** Harvard University.

Proton Shielding in Diborane,* C. W. Kern and W. N. Lipscomb,** *The Journal of Chemical Physics*, **37**, No. 2, 275-278 (July, 1962).

The chemical shift of the bridge proton relative to the terminal proton in diborane is discussed in several approximations based on Pople's and on Ramsey's atomic and molecular theories of magnetic shielding, respectively. The analysis, which depends on Yamazaki's 12-electron SCF LC-STO MO wave function, gives the result, generally observed in the H^1 NMR spectra of the higher hydrides, that the bridge protons show resonance at higher fields than do the BH_2 terminal ones.

* Work done while at Harvard University.

** Harvard University.

Qualitative and quantitative Aspekte des Grenzschnitt-verstärkers (Qualitative and quantitative aspects of the fluid switching element), R. A. Comparin,* A. E. Mitchell and H. R. Müller, *Zeitschrift für angewandte Mathematik und Physik* (ZAMP), **XIII**, 502-510 (September, 1962).

Visualization of flow pattern in a fluid switching element has shown that a separation bubble is formed. The flow separates at the nozzle and reattaches to the boundary wall downstream. Extensive work has been carried out on these phenomena in many different situations. It has been found that some of the phenomena associated with the fluid switching element can be explained in terms of the separation bubble. The paper describes the mechanism of the formation of the bubble. Photographs of the flow patterns in fluid switching elements are shown for a range of flow rates. Pressure distributions along the boundary wall are given. A minimum Reynolds-number has been found, which must be exceeded if the flow is to attach to a boundary wall. The dependence of this minimum on the geometrical configuration of the element is reported. The effect of an output load on the flow pattern and the influence of the wedge are shown. A short explanation of the switching action is given. Results on pressure and flow gain are reported and discussed.

* Now at the University of Maine, Orono.

Radiation Induced DC Electroluminescence in $ZnS:Mn$, M. J. Vogel, *Illuminescence of Organic and Inorganic Materials* (Proceedings of International Conference on Luminescence, October, 1961), John Wiley & Sons, New York, 612-614 (1962).

A non-electroluminescent phosphor, $ZnS:Mn$, was made dc-responsive by coating with an electrolyte and simultaneously exposing the coated surface to ultraviolet radiation and applying a dc current. The area so treated remains dc responsive when the ultraviolet is removed.

The Random Division of an Interval and the Random Covering of a Circle, L. Flatto* and A. G. Konheim, *SIAM Review*, **4**, 211-222 (July, 1962).

Let $\{P_i\}_{i=1}^{n-1}$ be $n-1$ independent random variables, each uniformly distributed on $[0, 1]$. The $\{P_i\}$ induce a partition of I into n segments. The authors study the distribution of the lengths of these segments employing a novel geometric method and relate these results to the random covering of

a circle by arcs of fixed length. The asymptotic behavior of the numbers of arcs needed to cover is obtained.

* Now at Yeshiva University.

Reaction of Oxygen Atoms with Acetylene to Form Ketene,* I. Haller and G. C. Pimental,** *Journal of the American Chemical Society*, **84**, 2855-2857 (August, 1962).

Nitrous oxide has been photolyzed at 20°K in solid argon containing acetylene C_2H_2 or a mixture of C_2D_2 and C_2HD . The photolysis source was a xenon resonance lamp emitting mainly at 1470 Å. This radiation produces ground state oxygen atoms (3P). Infrared spectra showed that the reaction occurred with C_2H_2 to produce absorption at 2143 cm^{-1} and with the deuterated acetylenes to produce absorptions at 2142 and 2117 cm^{-1} . The absorptions are assigned to ketene, thus showing that 3P oxygen atoms can react with acetylene to produce ketene. The activation energy for this reaction is below 8.1 Kcal/mole.

* Work performed at the Department of Chemistry, University of California.

** University of California.

Second-Order Hyperfine and Zeeman Corrections for an (*sl*) Configuration,* A. Lurio, M. Mandel** and R. Novick*** *The Physical Review*, **126**, No. 5, 1758-1767 (June, 1962).

The complete Zeeman and hyperfine (dipole, quadrupole, and octupole) matrices are given for an (*sl*) configuration in intermediate coupling. From these are derived the second-order corrections to the zero-field hyperfine intervals for an (*sp*) configuration. In addition, we obtain the corrections appropriate to the crossing of certain of the hyperfine Zeeman levels of an (*sp*) 3P_1 state for atoms with spin- $\frac{1}{2}$ and spin- $\frac{3}{2}$ nuclei.

* Work supported in part by the U. S. Air Force; monitored by the Air Force Office of Scientific Research of the Air Research and Development Command.

** Stanford University.

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Silver Oxide: The Heat Capacity from 2 to 80°K and the Entropy; the Effects of Particle Size,* L. V. Gregor and K. S. Pitzer,** *Journal of the American Chemical Society*, **84**, 2664-2670 (July, 1962).

The heat capacity of Ag_2O has been measured from 2.2 to 80°K for a finely divided annealed sample and from 3.3 to 24°K for a macrocrystalline annealed sample. The anomalously high heat capacity originally observed in unannealed Ag_2O between 20 and 50°K is also found in the finely divided sample, though the anomalous region is smaller and narrower, and its maximum occurs at a lower temperature. No anomalous peak in the heat capacity of macrocrystalline Ag_2O is observed down to 3.3°K, but the heat capacity of this material is higher below 14°K than that of the finely divided sample. The heat capacity of the various samples of Ag_2O is discussed in terms of its unusual crystal structure, and a mechanism proposed to correlate the anomalous behavior of Ag_2O below 15°K and between 20 and 40°K. The mechanism involves the interaction of the two independent sublattices of the structure of Ag_2O , and it is proposed that for very small particles, there is a transition from a symmetric high-temperature structure to a slightly distorted low-

temperature structure in the vicinity of 20° to 30°K. Revised values of the thermodynamic properties of macrocrystalline Ag₂O at 298.15°K are given.

* Work performed at the Lawrence Radiation Laboratory, University of California.

** Now at Rice University, Houston.

The Silver-Silver Oxide Electrode; The Entropy of Mercuric Oxide,* L. V. Gregor and K. S. Pitzer,** *Journal of the American Chemical Society*, **84**, 2671-2673 (July, 1962).

Stable, reversible Ag-Ag₂O electrodes have been prepared by partial electrolytic reduction of Ag₂O mixed with finely divided Ag in contact with a platinum wire. There is no apparent difference in the equilibrium electrode potential for annealed and unannealed Ag₂O, provided that there is no great change in particle size. The average potential for the cell reaction $2\text{Ag} + \text{HgO} \rightarrow \text{Ag}_2\text{O} + \text{Hg}$ is -0.2447 ± 0.001 v at 25°. The free energy of formation of Ag₂O at 25° is -2691 ± 10 cal/mole. Limited measurements of dE°/dT were made, and the value of -0.000201 ± 0.00001 v/deg used to calculate $\Delta S^\circ = -9.27 \pm 0.5$ cal/deg mole for the cell reaction. This value together with the entropies of Ag, Hg and Ag₂O yields 17.4 ± 0.6 cal/deg mole for the entropy of HgO at 298°K. Other cell data give concordant values for the entropy of HgO, but the result obtained from heat capacity data extrapolated from 15°K is appreciably smaller.

* Work performed at the Lawrence Radiation Laboratory, University of California.

** Now at Rice University, Houston.

Simulation of Human Problem-Solving Behavior, K. R. Laugherty,* *Psychometrika*, **27**, No. 3, 265-282 (September, 1962).

In the simulation of human behavior on a digital computer, one first attempts to discover the manner in which subjects (Ss) internally represent the environment and the rules that they employ for acting upon this representation. The interaction between the rules and the environmental representation over a period of time constitutes a set of processes. Processes can be expressed as flow charts which, in turn, are stated formally in terms of a computer program. The program serves as a theory which is tested by executing the program on a computer and comparing the machine's performance with S's behavior.

* Carnegie Institute of Technology.

Spectroscopy and Optical Maser Action in SrF₂:Sm⁺², P. P. Sorokin, M. J. Stevenson, J. R. Lankard and G. D. Pettit, *The Physical Review*, **127**, 503-508 (July, 1962).

Results of spectroscopic and optical maser measurements in SrF₂:Sm⁺² are presented. This system differs from CaF₂:Sm⁺² by having a four-orders-of-magnitude longer radiative lifetime. The reasons for the difference in τ values and the effects of this difference upon maser kinetics are presented.

Spin Resonance Spectra of Substituted Aromatic Ions; Superposition Model, J. C. Schug,* T. H. Brown** and M. Karplus, *The Journal of Chemical Physics*, **37**, No. 2, 330-339 (July, 1962).

A simplified model is developed for the extension of the valence-bond method to certain types of substituted aromatic ions. The model assumes that the ground-state wave function can be decomposed into quasi-independent charge distributions whose interactions can be analyzed by perturbation theory. The resulting formulation permits the approximate superposition of the results of electron spin resonance measurements of mono-substituted species to estimate hyperfine constants of poly-substituted ions. By this very simple averaging technique, reasonable agreement with experiment is obtained in certain cases and significant deviations occur in others. Also a number of relationships (e.g. constancy of $a_2^H + a_3^H$ in para-substituted nitrobenzene anions) are predicted or explained by the model.

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Statistical Stability of the Preisach Diagram for Particles of $\gamma\text{-Fe}_2\text{O}_3$, G. Bate, *Journal of Applied Physics*, **33**, No. 7, 2263-2269 (July, 1962).

An experiment is described which enables the statistical stability of the Preisach diagram for interacting ferromagnetic particles to be tested. The samples used were of $\gamma\text{-Fe}_2\text{O}_3$ dispersed in a nonferromagnetic matrix to a nominal packing density of 20% by volume. Both oriented and nonoriented samples were examined. In every case the diagram was found to be stable over most of the area bounded by the major remanence loop. The region of departure from stability occurred at the higher levels of remanent intensity. A method of calculating the diagrams using only dc measurements is given. They are then used to predict accurately the ascending remanence curve after ac demagnetization for each sample. Finally, it is shown how the experimental ascending and descending remanence curves, which could not be explained by Wohlfarth's relations* based on noninteracting particles, can be completely described in terms of the Preisach diagram.

* E. P. Wohlfarth, *J. Appl. Phys.*, **29**, 595 (1958).

Some Theorems for Incompletely Specified Sequential Machines with Applications to State Minimization, J. Beatty and R. E. Miller, *Switching Circuit Theory and Logical Design* (Proceedings of the Third Annual AIEE Symposium), 124-136 (September, 1962).

Let M be an incompletely specified sequential machine. The problems of finding either one or all machines with a minimum number of internal states which "satisfy" M are considered. Such minimum-state machines are known to correspond to minimum closed collections of compatible sets of states of M . Several types of compatible sets are shown to be superfluous in the sense that (1) at least one minimum state machine and (2) all minimum state machines can be found without using these sets. Algorithms for state minimization are described using these results.

Theoretical and Experimental Investigation of Thermal Stresses in Hypersonic-Aircraft Wing Structures, H. Tramposch, *Journal of the Aerospace Sciences*, **29**, No. 6, 719-726 (June, 1962).

A simple and relatively accurate analytic approximation is developed to determine the temperature and thermal-stress

distribution in aircraft wing structures. Theoretical investigations show that the results of the existing thermal-stress theories which neglect the temperature gradient through the skin thickness may exceed, in the range of higher Biot numbers, the true values by more than 30 percent.

Refined photothermoelastic experiments verify these results and add another significant conclusion. They indicate that thermal stresses in wing structures generated by a variable heat-transfer coefficient coincide with the theoretical predictions which are based on a constant heat-transfer coefficient, as long as the latter represents the arithmetic average over the heating cycle and the variation is in the order of ± 10 percent. However, even much greater variations in the order of ± 100 percent produce only relatively small differences.

Theoretical Treatment of Ellipsometry, F. Partovi, *Journal of the Optical Society of America*, **52**, No. 8, 918-925 (August, 1962).

Exact expressions are obtained in closed form for the phase and amplitude of the reflected light when a light beam is incident upon a multilayer of a number of homogeneous media. The assumption is made that Maxwell's equations and Ohm's law hold. These equations are applied to the special case of dielectric coated metals and the results are compared to ellipsometry measurements made in chromium slides covered with barium stearate films of known thickness. When the conductivity and the dielectric constant of the metal are allowed to assume complex values, and when precautions are taken to reduce the inaccuracy introduced by the residual oxide and gas layer on the metal, the agreement is good.

Thermal Oxidation of Silicon, T. H. Yeh, *Journal of Applied Physics*, **33**, No. 9, 2849-2850 (September, 1962).

The results of a laboratory investigation of silicon-silicon dioxide film produced by high-temperature thermal oxidation of silicon in water vapor shows: (1) the oxidation rate in steam is dependent on the doping impurity concentration of the crystal, and (2) the oxidation in steam at 970°C for various lengths of time of phosphorus-diffused wafers with surface concentration of $2 \times 10^{21} \text{ cm}^{-3}$ results in an impurity pile-up region near the silicon surface. On the other hand, boron-diffused wafers with surface concentration in the order of $5 \times 10^{18} \text{ cm}^{-3}$ deplete their impurity concentration near the silicon surface.

Thin Film Micro-Circuit Networks, W. N. Carroll, *Electronic Reliability and Microminiaturization* (International Journal), **1**, 163-169 (1962).

This paper describes the fabrication and operational testing of several types of thin film circuit networks which were fabricated by using vacuum-evaporated elements deposited in a three-dimensional or multilayered structure. Data on the fabrication processes, the component stability and reproducibility, and circuit operational performance are given.

Time Average Thermal Properties of a Computer Utilizing Thin-Film Superconducting Elements,* H. Sobol,** *IRE Transactions on Electronic Computers*, **EC-11**, No. 2, 200-212 (April, 1962).

It is necessary to understand the static thermal properties of cryotron gates before one can predict the limitations asso-

ciated with dissipative heating of a complex cryotronic computer. An experimental program has been conducted to determine the thermal properties of isolated and of thermally coupled gates. All experiments reported in this paper were performed on tin gates evaporated onto glass substrates.

The total thermal conductance K of a gate is defined, and experimental values of K are presented as a function of power and gate geometry. An analysis of the heat flow is given, based on a temperature-dependent coefficient of heat transfer. Theoretical values of K and temperature distribution are derived. The theory qualitatively predicts the temperature variation. Finally, the results are extrapolated to estimate the number of cryotrons that can be used safely in a thermally coupled system.

* Supported by the Bureau of Ships, U.S. Navy.

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Tracking Ships by Electronic Computer,* T. A. Throop, *Computers and Automation*, **11**, 12-16 (September, 1962).

The U.S. Navy is interested in monitoring the location and destination of all friendly ships at sea by means of electronic computing equipment. This is important for the detection of enemy ships, for air-sea rescue operations, and for answering queries about past, present or future ship locations. The tracking of ships by an electronic computer involves two problems. First of all, the route which a ship is presumed to be following must be generated. Secondly, the ship's predicted position must be updated hourly or otherwise. The article describes a method, which has been programmed successfully for the UNIVAC 1 and IBM 704, by which the land masses of the world are represented, the route between any two points of the world generated, and a ship's position updated.

* Work performed at The Applied Mathematics Laboratory, David Taylor Model Basin, Washington, D.C.

Transport of Solid through the Gas Phase Using a Single Heterogeneous Equilibrium, R. F. Lever, *The Journal of Chemical Physics*, **37**, No. 6, 1174-1176 (1962).

A model is developed for one-dimensional steady-state diffusion-limited transport of solid between source and seed planes in the presence of a known chemical equilibrium. The transport depends on the reaction enthalpy, the separation and temperature difference between source and seed, and the departure from equilibrium at the crystal surfaces. A simple expression gives the dependence of transport on the gaseous binary diffusion coefficients, the reaction coefficients, and mean partial pressures of the various species present.

Using Solar Cells to Read Holes, A. S. Athens, *Electronic Design*, **10**, 78-81 (February, 1962).

Silicon photovoltaic cells have now become acceptable for high-speed paper tape and card reading. Designing reliable circuits with solar cells is not difficult, if the designer is aware of how the operating point moves on the device's characteristic curve.

Walnut Document Storage and Retrieval System, N. A. Vogel, *Proceedings of the Eleventh Annual Meeting and Convention of the National Microfilm Association*, Annapolis, Maryland, 26-39 (1962).

A large-scale document indexing, storage and retrieval system, with the code name "Walnut," is being developed by IBM. The system is made up of two related but independent and free-standing subsystems: (1) the index-computer system, and (2) the image file and reproduction system. Each image file module contains 200 independent, easily removable cells, each capable of storing images of 4950 pages on film strips. All document images are permanently retained in the image file, and thus are immediately available for automatic reproduction on aperture cards when requested.

Letters to the Editor

Boiling Water Oxidation Rates on Silicon, J. W. Beck, *Journal of Applied Physics*, **33**, 2391 (July, 1962).

The Coherent Memory Spectrum Analyzer with Loop Gain $K < 1$, W. R. Remley, *Proceedings of the IRE*, **50**, 1984-1985 (September, 1962).

Elektronenmikroskopische Beobachtungen von Versetzungen in Germanium* (Electron-microscopic Observations of Dislocations in Germanium), H. Alexander** and S. Mader, *Acta Metallurgica*, **10**, 887-890 (September, 1962).

* Work performed at Max-Planck-Institut für Metallforschung, Stuttgart, Germany.

** Institut für Metallphysik der Universität Göttingen, Göttingen, Germany.

Magnetschichtspeicher des IBM — Forschungslabors Zürich (Thin Magnetic Film Memory of the IBM Research Laboratory, Zurich), G. Kohn, *Nachrichtentechnische Zeitschrift (NTZ)*, **8**, 380 (1962).

The Number of Possible Auctions at Bridge, W. E. Langlois, *American Mathematical Monthly*, **69**, 634 (August-September, 1962).

Structure in the Excess Current Region of Gallium Arsenide Tunnel Diodes, R. W. Hamaker and H. F. Quinn, *Journal of Applied Physics*, **33**, No. 7, 2396 (July, 1962).